6.2 CALIBRATION OF THE EVERGLADES AND THE LEC

The goal of the Everglades/LEC calibration effort was to make simulated stages at selected monitoring/observation points and canals, and simulated discharges through selected structures match historical data as reasonably close as possible. All historical input data, including structure flows, were assumed to be reliable. The question of data reliability will be addressed to some extent in Chap. 7. The model is calibrated on a regular basis to ensure that its history matching capability is maintained or improved after computer code changes and data updates have been performed. It must be emphasized that calibration also enhances, but not guarantee, a model's predictive capability.

Methodology

A network of groundwater monitoring or observation wells is maintained by the District and the USGS. Observations from this network were used to make stage comparisons during calibration (Fig. 6.2.1). Although the simulation was performed on a daily basis, only end-of-month water levels were compared with historical data. Comparing historical data with simulated values on a daily basis was not justifiable because of several factors:

1. The spatial resolution of the model, 2 miles by 2 miles, is too coarse for modeling local phenomena such as wellfield drawdowns and levee seepage.
2. The time resolution of the model, 1 day, may not always satisfy certain assumptions in the model. For example, in the overland flow subroutine, in order to maintain stability in the solution procedure, volume constraints during some simulation days may override the assumption that overland flow is a diffusion type process.
3. The availability or lack of continuous flow and stage information preclude daily comparison of historical data and simulated values. Even if data is available, daily comparison is statistically noisier than weekly or monthly comparison.
4. The intended use of the model is to provide long-term planning-type guidance to water managers with regards to making water policy decisions. The model is not intended to estimate system responses to extreme conditions whose timing may be in the order of hours or even minutes (e.g. flood events). It is also not intended to be a prescriptive model that a field operator can use in making decisions on when and by how much to open a sluice gate, for instance, on a day-to-day basis.

Canal stages were also considered in the calibration. Due to the more dynamic nature of canal levels relative to groundwater levels, as well as the coarse representation of canals in the model (refer to Sec. 2.5), a comparison of average monthly stages was selected.

In general, the time series of historical flows, where available and considered reliable, were input for structures. Some sparse and/or unreliable historical data, e.g., discharge at coastal structures, were compared to simulated data on a monthly and annual bases.

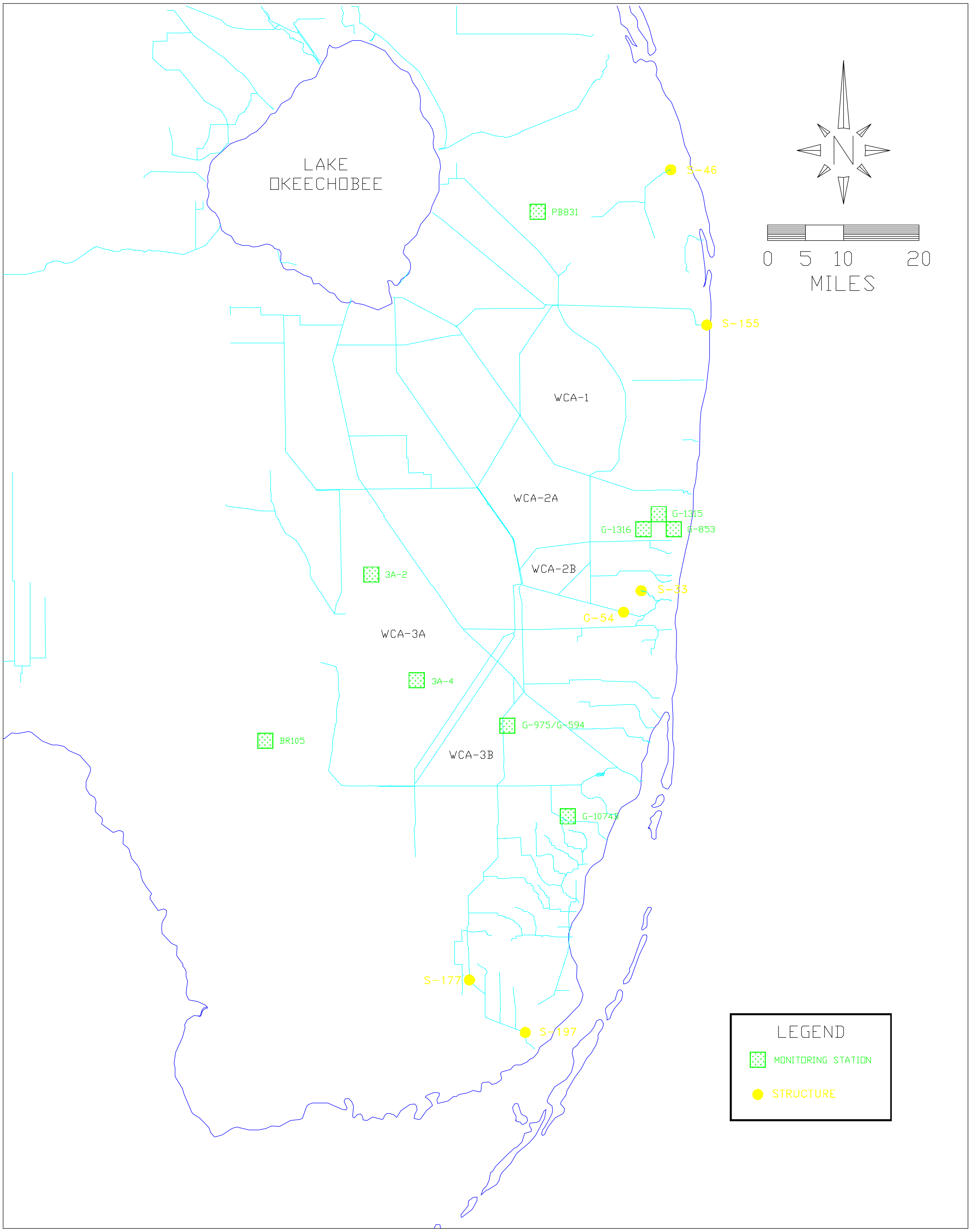

Figure 6.2.1 Location of Selected Groundwater Level Monitoring or Observation Wells Used in the South Florida Water Management Model Calibration

Calibration for the majority of the model domain (LEC, WCA, ENP, and BCNP) was performed in an iterative fashion: (1) simulated stages were compared with historical stages at selected monitoring points and simulated flows were compared with historical flows at control structures; (2) appropriate calibration parameters were modified in order to make simulated values match historical values more closely; (3) the model was rerun with the revised parameters; and (4) step (1) was repeated until an acceptable match between simulated and historical values was obtained.

The use of historical flows as boundary conditions at certain structures, instead of actually simulating the discharge through those structures during calibration, allowed physical processes to be calibrated without being affected by possible changes to operating practices. One of the strengths of the SFWMM is its ability to show the response of groundwater levels to water resources management. Historical flows, which are determined by structure hydraulics as well as structure operating rules, encapsulate field-level decision making processes, which may deviate from what is specified in operating manuals.

Several parameters can be adjusted to calibrate the Everglades and LEC portions of the model domain. A breakdown of the most significant parameters used in the calibration procedure is given below.

A. Lower East Coast
- **1.** Canal parameters:
  - **a.** channel - aquifer hydraulic conductivity coefficient [CHHC in Eq. (2.4.1)];
  - **b.** surface water - channel interaction [*n* in Sec. 2.5];
  - **c.** coefficients for operation of outlet structures;
- **2.** Detention depths (refer to Sec. 2.3); and
- **3.** ET coefficients (KVEG, DSRZ, DDRZ in Sec. 2.2).

B. Everglades (WCAs, ENP and BCNP)
- **1.** ET coefficients (KVEG, DSRZ, DDRZ in Sec. 2.2)
- **2.** Manning's n ($n = Ah^b$ for overland flow; mainly A is adjusted);
- **3.** Levee seepage rate coefficients [β_0 , β_1 , β_2 , in Eq. (2.4.2)];
- **4.** Detention depths (refer to Sec. 2.3); and
- **5.** Canal parameters (refer to Secs. 2.4 and 2.5).

The general guidelines used in calibrating the model were discussed in Chap. 6. Additional guidelines specific to the Everglades/LEC region are listed below.

1. The calibration period covered historical data consistent with a relatively static “plumbing” system and constant structure operating rules.

2. Local parameters such as canal properties and cell-based data, were adjusted before regional parameters were adjusted. Regional parameters such as land use type have greater areal influence. This procedure was followed to minimize the undesirable effect of the calibration getting better in some areas but negatively affecting other areas in the model domain.

3. Exact matching of historical data may not be desirable in some cells during the calibration process. The simulated stage represents the average water level computed for a 4-mile^2 area. Comparing historical stage, a point measurement, against simulated stage, an estimated areal average, is a source of discrepancy in itself. Some monitoring points are located near a municipal wellfield which can heavily influence the stage at that location. Since the model cannot accurately simulate wellfield drawdowns at such a small scale, matching stages at that particular location becomes a futile effort. Good engineering judgement must be used.

4. It was shown (Trimble, 1995a) that canals heavily influence groundwater levels within its immediate proximity. The monitoring point closest to the canal, assuming that several observation points exist within the cell where the canal is located, gets priority for the stage matching.

5. following statistical measures and their corresponding ranges were used to evaluate the status of the calibration after each parameter change.

coefficient of determination or correlation coefficient, $\mathbf{R^2}$:

$$R^2 = \frac{\dfrac{1}{n-1} \sum_{i=1}^{n} (x_i - x_m)\ (\hat{x}_i - \hat{x}_m)}{\sqrt{\sum_{i=1}^{n} (x_i - x_m)^2 \sum_{i=1}^{n} (\hat{x}_i - \hat{x}_m)^2}} \quad ; \quad 0 \le R^2 \le +1 \qquad (6.2.1)$$

mean square error, **mse** :

$$mse = \frac{\sum_{i=1}^{n} (\hat{x}_i - x_i)^2}{n-1} \quad ; \quad 0 \le mse \le +\infty \qquad (6.2.2)$$

bias:

$$bias = \frac{\sum_{i=1}^{n} (\hat{x}_i - x_i)}{n} \quad ; \quad -\infty \le bias \le +\infty \qquad (6.2.3)$$

where:

n = number of data points;
x_i = observed data point;
x_m = mean of observed data points;
$\hat{x}_i$ = simulated data point; and
$\hat{x}_m$ = mean of simulated data points.

The selected calibration period includes calendar years 1979 through 1990. Because the South Dade Conveyance System (SDCS) was completed in 1982, the calibration during the first three years of the selected period was relaxed for that region of the model domain.

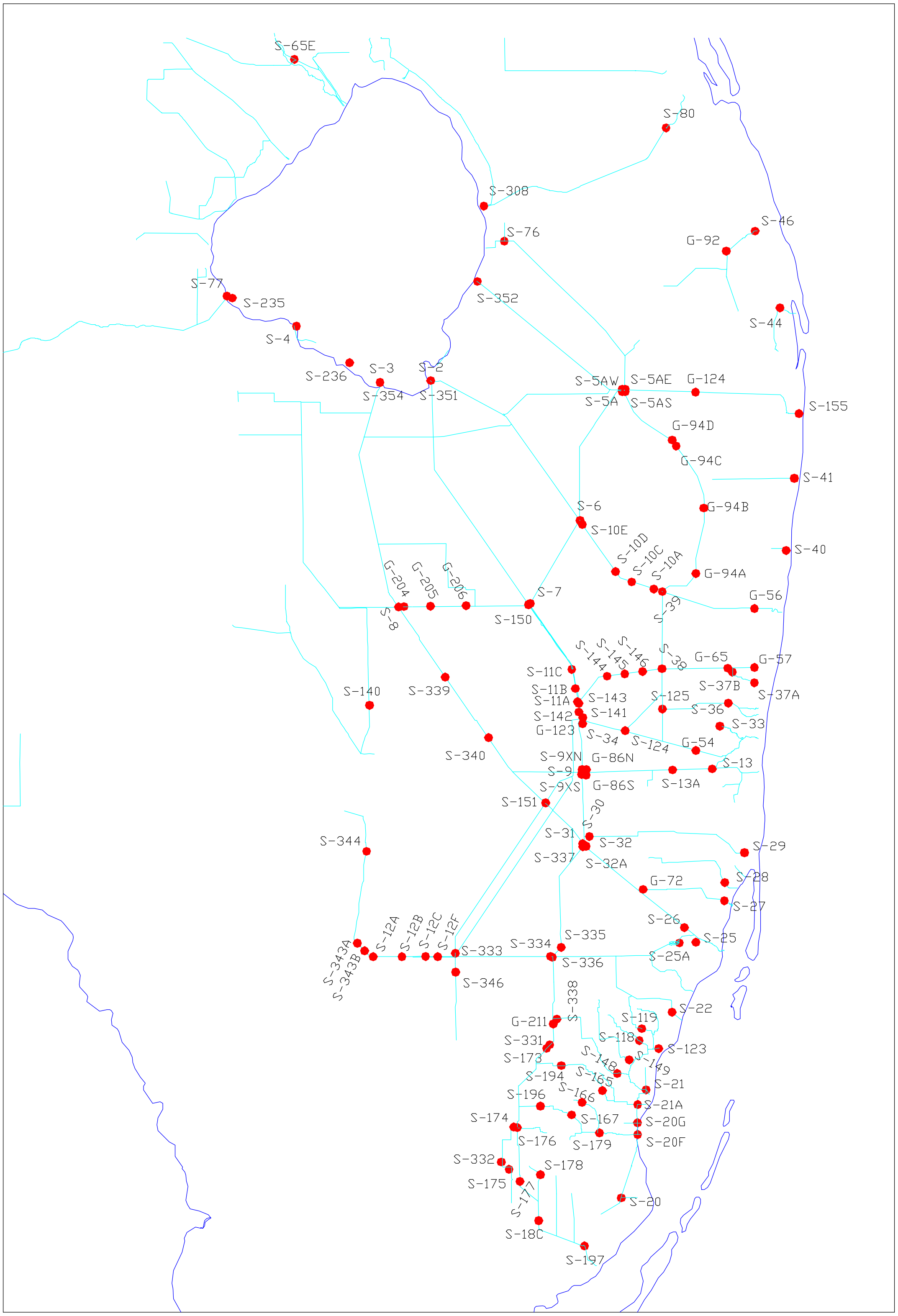

Figure 6.2.2 Location of Major Control Structures Simulated in the South Florida Water Management Model

Everglades and LEC Calibration Results

Calibration results for the Everglades (WCAs and portions of the ENP and the BCNP) and LEC Service Areas are presented next. The figures that follow show representative comparisons of month-end stages for various monitoring points and monthly average stages for several canals throughout the model domain. Comparisons of simulated and historical monthly and annual flow volumes are also included for selected structures. Figs. 6.2.1 and 6.2.2 can be used to locate the gages referenced in the following discussion. Appendix B contains the full set (174 monitoring points and 35 canal locations) of calibration plots based on the SFWMM v2.8.

Figs. 6.2.3(a) and (b) compare historical and simulated stage time series for monitoring points G975 and G594, both of which are located in the same SFWMM grid cell (x,y: 27,28). Borrow canal L-30 goes through this cell. Since groundwater levels in the vicinity of canals are heavily influenced by canal levels, it follows that G594 should be the preferred basis for comparing stages at this location.

The effect of wellfields on the system is illustrated in Figs. 6.2.4(a) and (b). G1074B (x,y: 31,20) is located within the cone of influence of the Alexander Orr, Jr. wellfield in Dade County, and G853 (x,y: 38,39) is situated in the same SFWMM grid cell where the Northeast wellfields of the city of Pompano Beach in Broward County are located. In both instances, the model is unable to track the wide fluctuations in groundwater levels at these two sites. This discrepancy could be reduced only if finer grid cells and/or finer time scales were used.

Another limitation of the model is related to one of the assumptions used to route water through canals: the water surface profile in a canal reach is assumed to have a constant slope, HDC (refer to Sec. 2.5). In Figs. 6.2.5(a) and (b), two gaging stations, G1315 (x,y: 37,40) and G1316 (x,y: 36,39), are located on opposite ends of one of the secondary canals maintained by the Deerfield Agricultural District just south of the Palm Beach-Broward county line. The model simulates stages in the upstream monitoring point (G1315) better than it does on the downstream end (G1316). Although the difficulty presented by these two gaging stations to the entire calibration effort do not occur frequently, suggested model improvements, in addition to better data collection, to offset it are: (1) include a time-varying HDC; or (2) revise the canal routing algorithm to be consistent with the more accurate distributed flow routing techniques.

The importance of regional parameters, such as ET parameters, which are functions of land use, is illustrated in Figs. 6.2.6(a) and (b). PB831 (x,y: 29,60), located in northwestern Palm Beach county, and BR105 (x,y: 11,25), located in southeastern Collier county within the Big Cypress National Park, are both located in grid cells with the same land use classification: forest. During dry periods, PB831 tends to overestimate stages while BR105 tends to underestimate stages. Since both monitoring points are located within the same type of "natural" areas, candidate parameters for calibration are limited to ET parameters. Adjusting such parameters will have conflicting effects at the two locations. A decision was made to emphasize stage matching for PB831 since it is closer to urban development where related water management issues have to be made. This example illustrates that some times subjectivity may be required in model calibration.

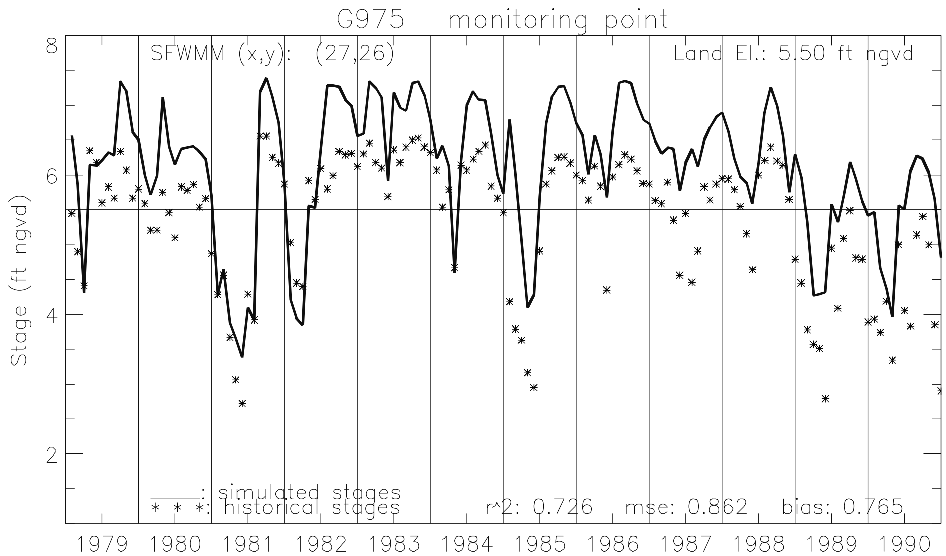

Figure 6.2.3(a) Comparison of Simulated and Historical End-of-Month Stages at Gage Location G975 for Period of Record 1979-1990

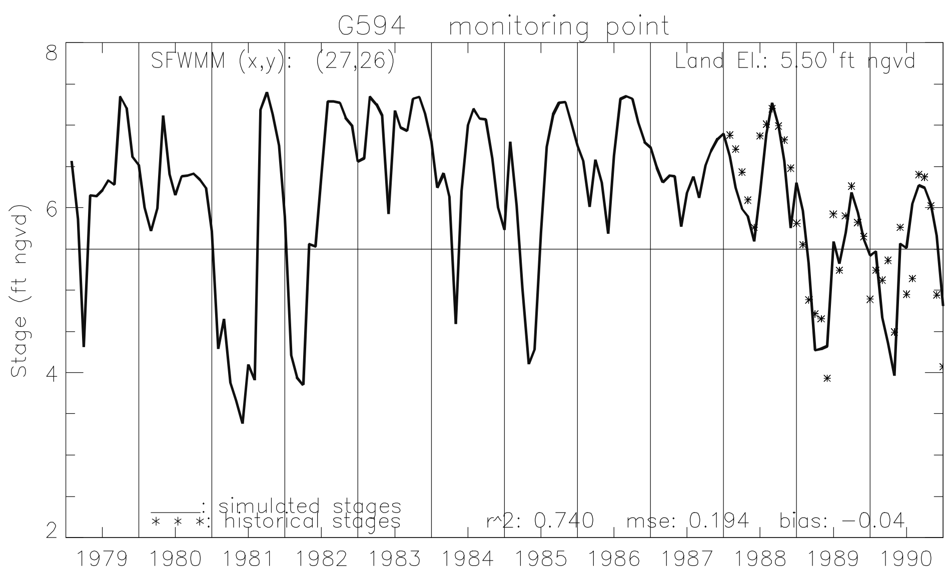

Figure 6.2.3(b) Comparison of Simulated and Historical End-of-Month Stages at Gage Location G594 for Period of Record 1979-1990

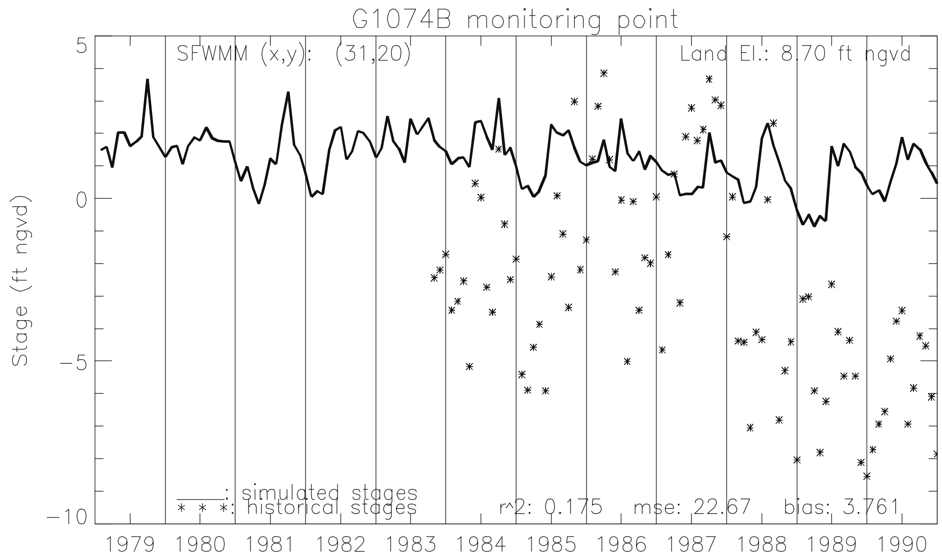

Figure 6.2.4(a) Comparison of Simulated and Historical End-of-Month Stages at Gage Location G1074B for Period of Record 1979-1990

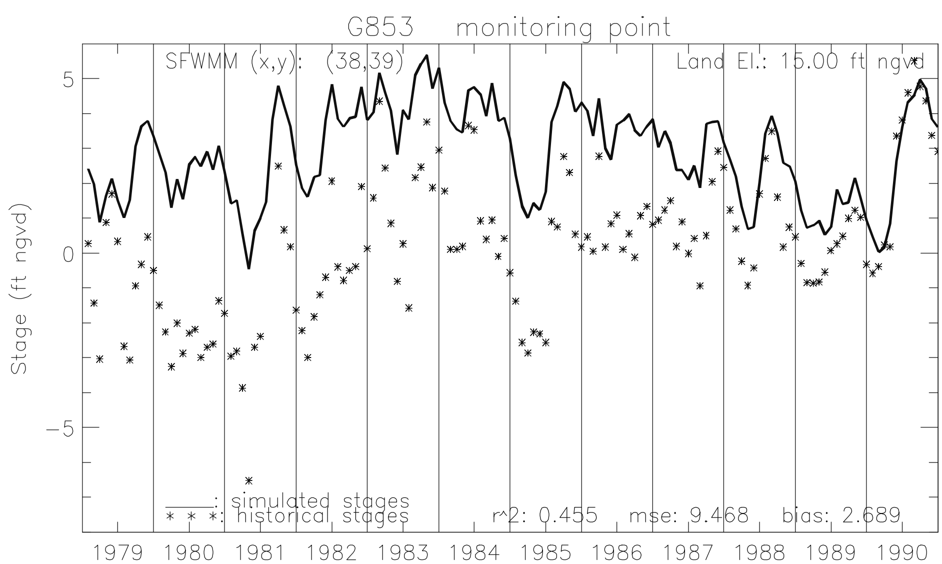

Figure 6.2.4(b) Comparison of Simulated and Historical End-of-Month Stages at Gage Location G853 for Period of Record 1979-1990

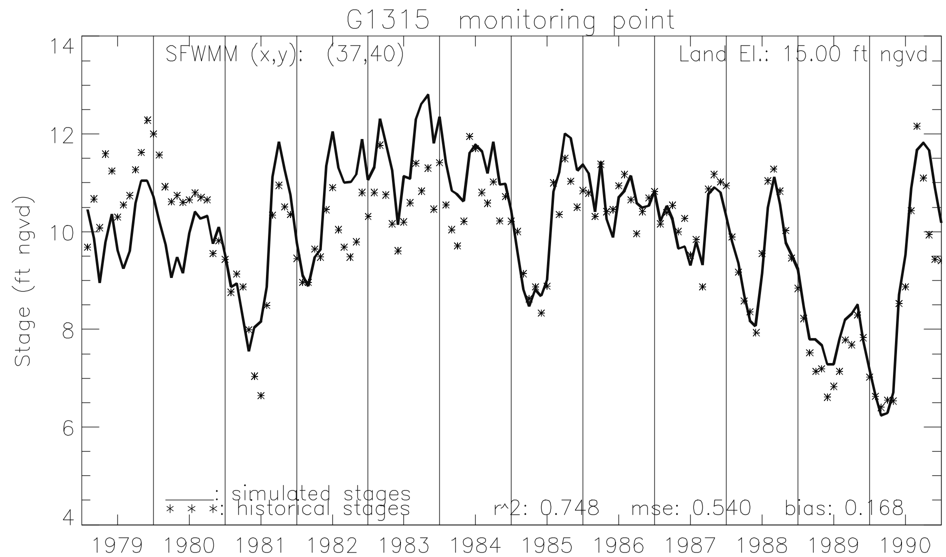

Figure 6.2.5(a) Comparison of Simulated and Historical End-of-Month Stages at Gage Location G1315 for Period of Record 1979-1990

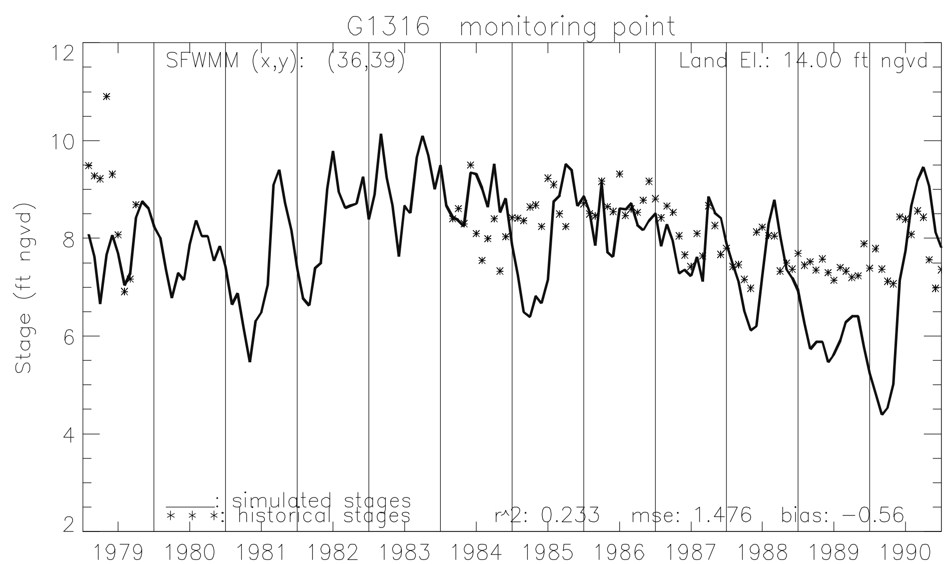

Figure 6.2.5(b) Comparison of Simulated and Historical End-of-Month Stages at Gage Location G1316 for Period of Record 1979-1990

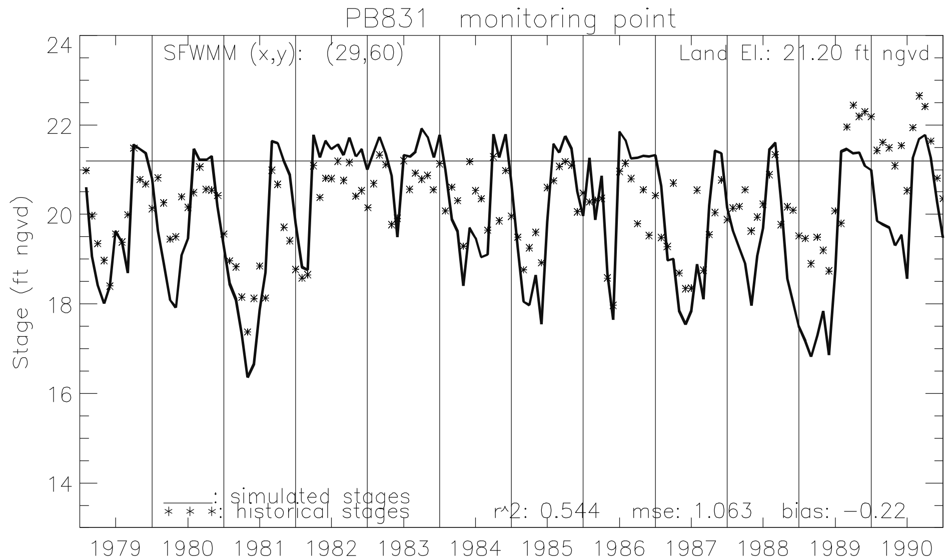

Figure 6.2.6(a) Comparison of Simulated and Historical End-of-Month Stages at Gage Location PB831 for Period of Record 1979-1990

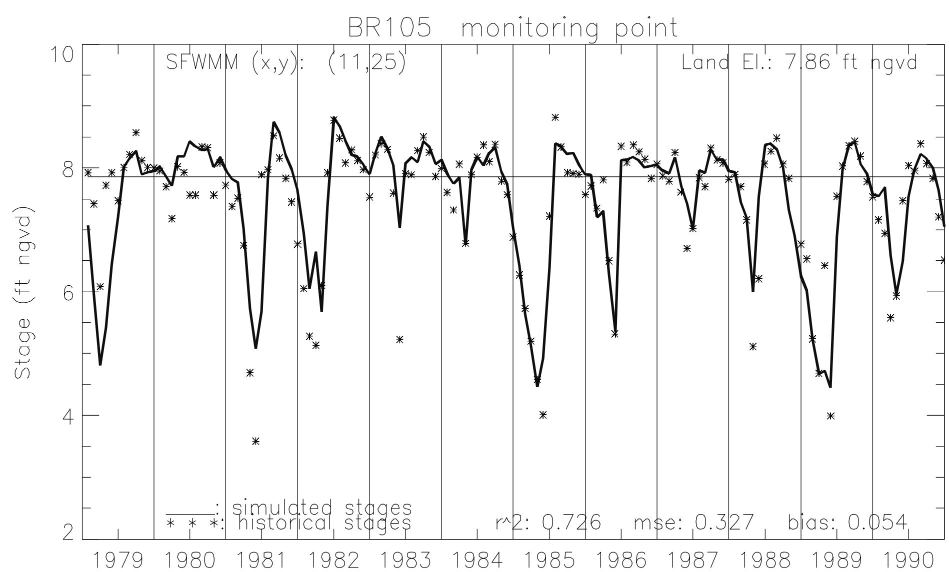

Figure 6.2.6(b) Comparison of Simulated and Historical End-of-Month Stages at Gage Location BR105 for Period of Record 1979-1990

Preferential stage matching in the model calibration may also be necessary in situations where a monitoring point is used to make operational decisions in the field. Gage 3A-4 (x,y: 21,29) is used as a basis for making regulatory discharges from WCA-3A. Additional effort was invested in improving the calibration at this location [Fig. 6.2.7(b)], in terms of minimizing overestimation of highs and underestimation of lows, as compared to 3A-2 (x,y: 18,36), a gaging station less than ten miles away [Fig. 6.2.7(a)] to the northwest of 3A-4. Both locations have the same vegetation type.

Historical values of canal stages measured at the headwater of the downstream structures (denoted by “Ref. Structure” in the calibration plots) are also compared to simulated stages during the calibration process. Figs. 6.2.8(a) and (b) are calibration plots for C-12 canal and the North New River Canal (NNRC). The model performs a fairly good simulation of canal stages for C-12 canal but fails to trace wide fluctuations in NNRC stages. During wet periods the gates at G-54 are open full allowing the headwater stage to be quite low. During these times the slope of the water surface is relatively steep and nonlinear in geometry. Since the channel flow routing uses a mass balance approach and assumes a constant slope (linear) profile, the greatest error in the simulated stage along the North New River Canal would be at the downstream structure: G-54. The linearity assumption on the water surface slope becomes more valid further upstream.

As mentioned earlier, the selection of the calibration period (1979-1990) was largely dictated by the completion of the infrastructure associated with the South Dade Conveyance System in 1982. Figs. 6.2.9 and 6.2.11 show the calibration of stages and flow volumes at S-177, one of the major structures in the SDCS. More emphasis was made in matching historical stages and flow volumes after 1982. Historical stages and flow volumes for 1989 and 1990 deviate significantly from simulated values. This discrepancy may be due to operational policies instituted for SDCS during those two drought years.

Another operational change that might explain substantial deviations between historical and simulated stages can be illustrated in Fig. 6.2.10. Recorded low stages between 1982 and 1984 for the C-51 canal imply that the gates at its downstream structure, S-155, were opened earlier than usual, i.e., the actual canal maintenance level is lower during this two-year period. The model assumes fixed operational policies during a given simulation period and therefore, does not capture deviations from the "normal" maintenance level. On a positive note, Fig. 6.2.12 represents probably the best calibration information that the model can offer as far as matching historical flow volumes out of coastal structures. In general, flow volume trends on an annual, dry- and wet-season bases are sufficiently simulated by the model.

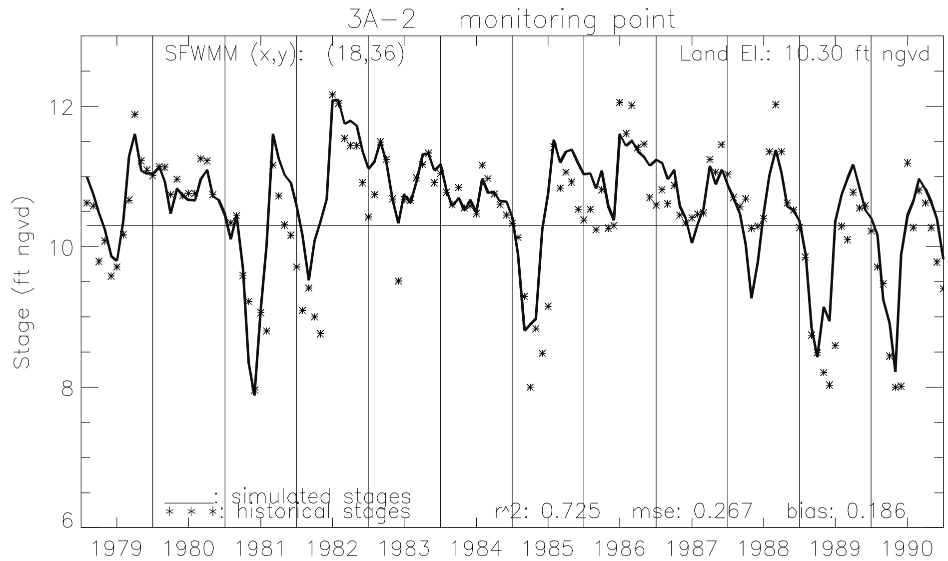

Figure 6.2.7(a) Comparison of Simulated and Historical End-of-Month Stages at Gage Location 3A-2 for Period of Record 1979-1990

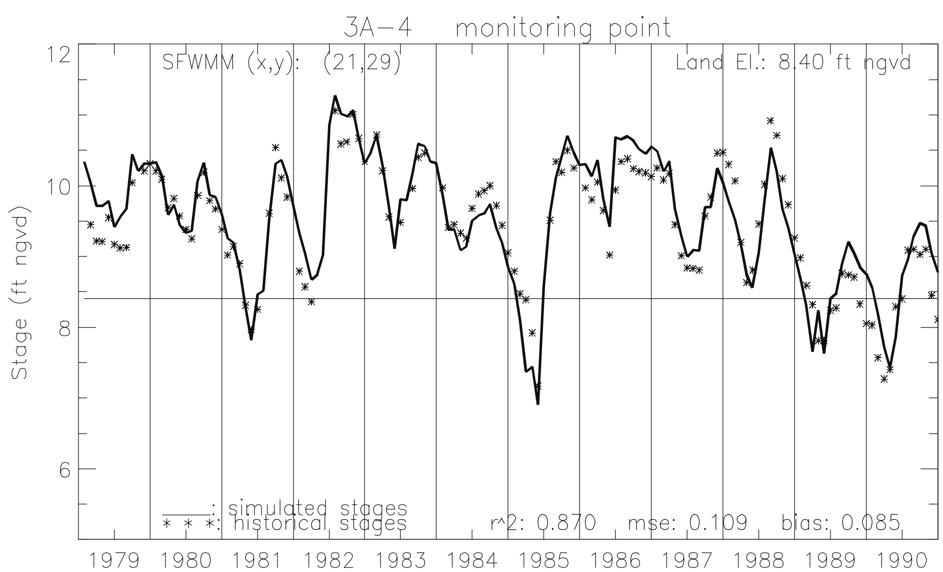

Figure 6.2.7(b) Comparison of Simulated and Historical End-of-Month Stages at Gage Location 3A-4 for Period of Record 1979-1990

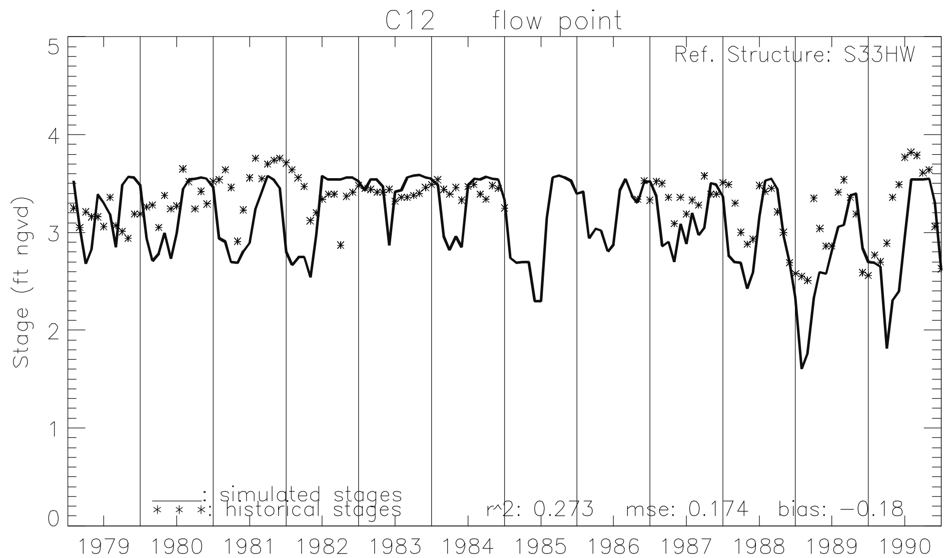

Figure 6.2.8(a) Comparison of Simulated and Historical Mean Monthly Stages along C-12 Canal (S-33HW) for Period of Record 1979-1990

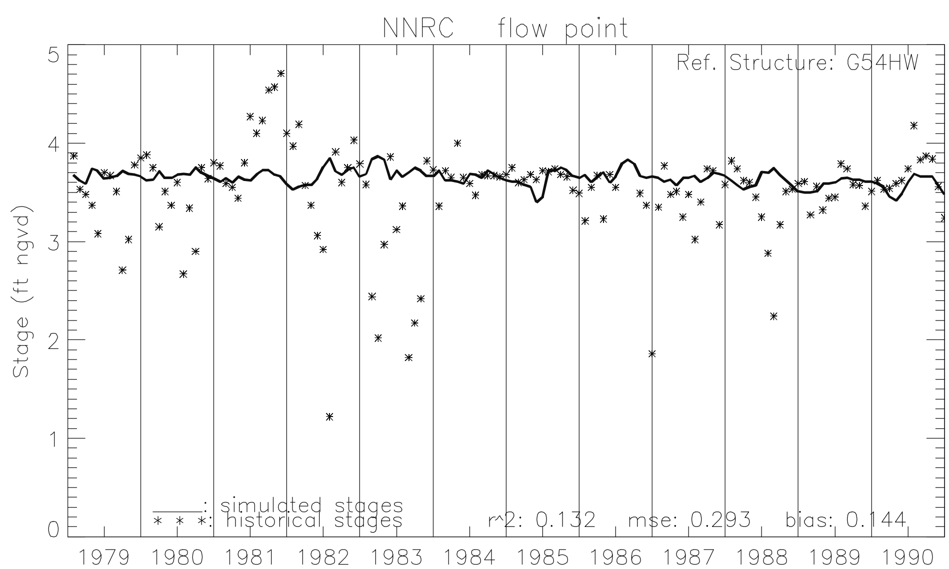

Figure 6.2.8(b) Comparison of Simulated and Historical Mean Monthly Stages along NNRC (G-54HW) for Period of Record 1979-1990

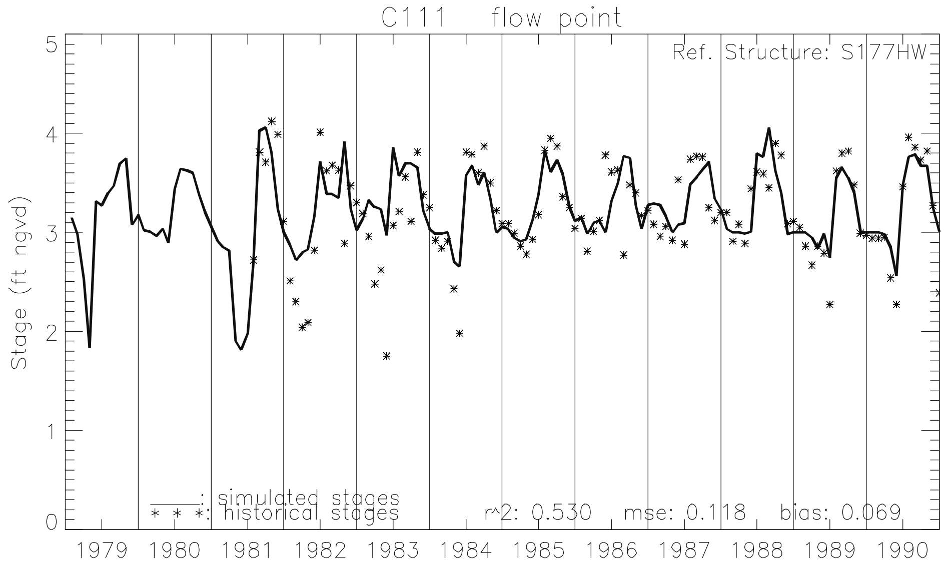

Figure 6.2.9 Comparison of Simulated and Historical Mean Monthly Stages along C-111 Canal (S-177HW) for Period of Record 1979-1990

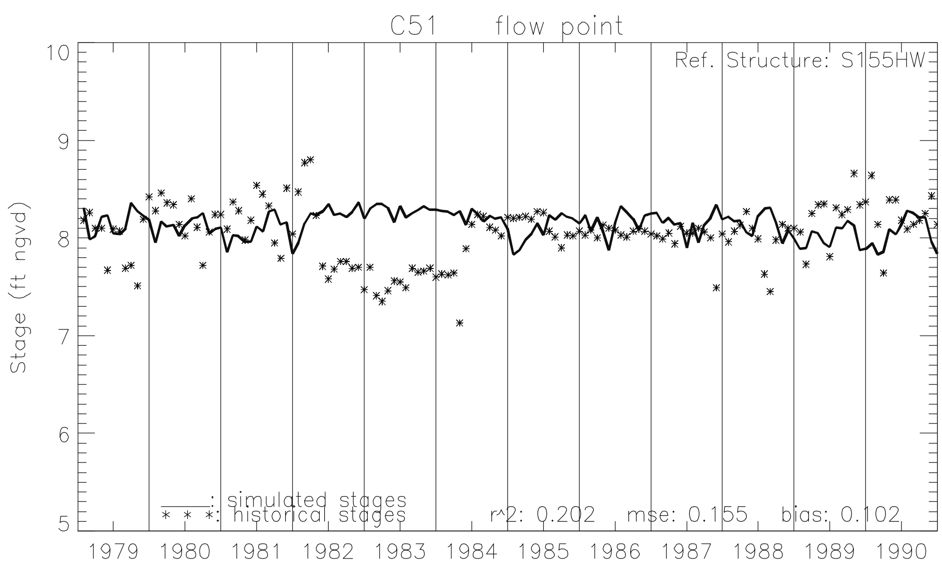

Figure 6.2.10 Comparison of Simulated and Historical Mean Monthly Stages along C-51 Canal (S-155HW) for Period of Record 1979-1990

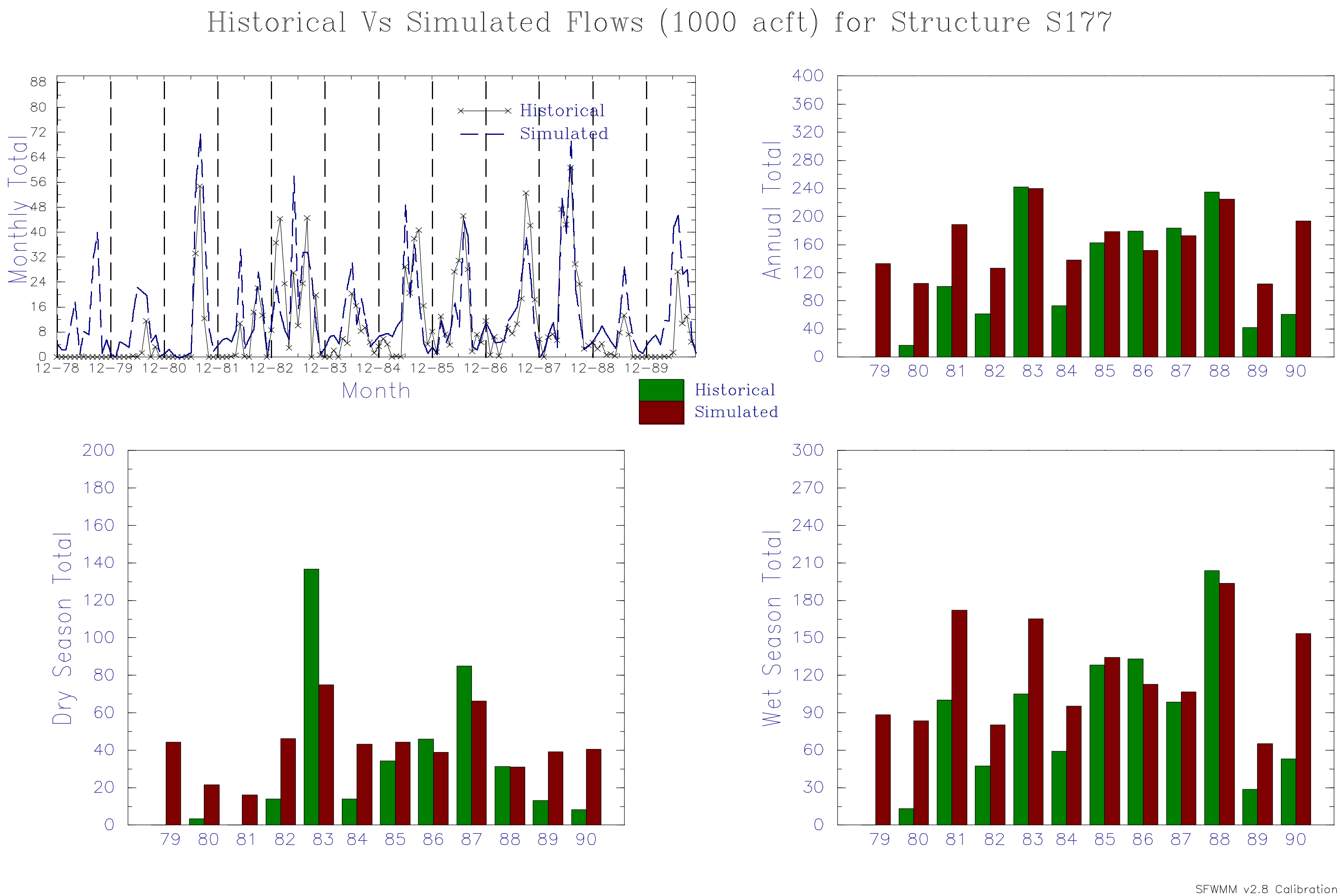

Figure 6.2.11 Comparison of Simulated and Historical Flows at Structure S-177 for Period of Record 1979-1990

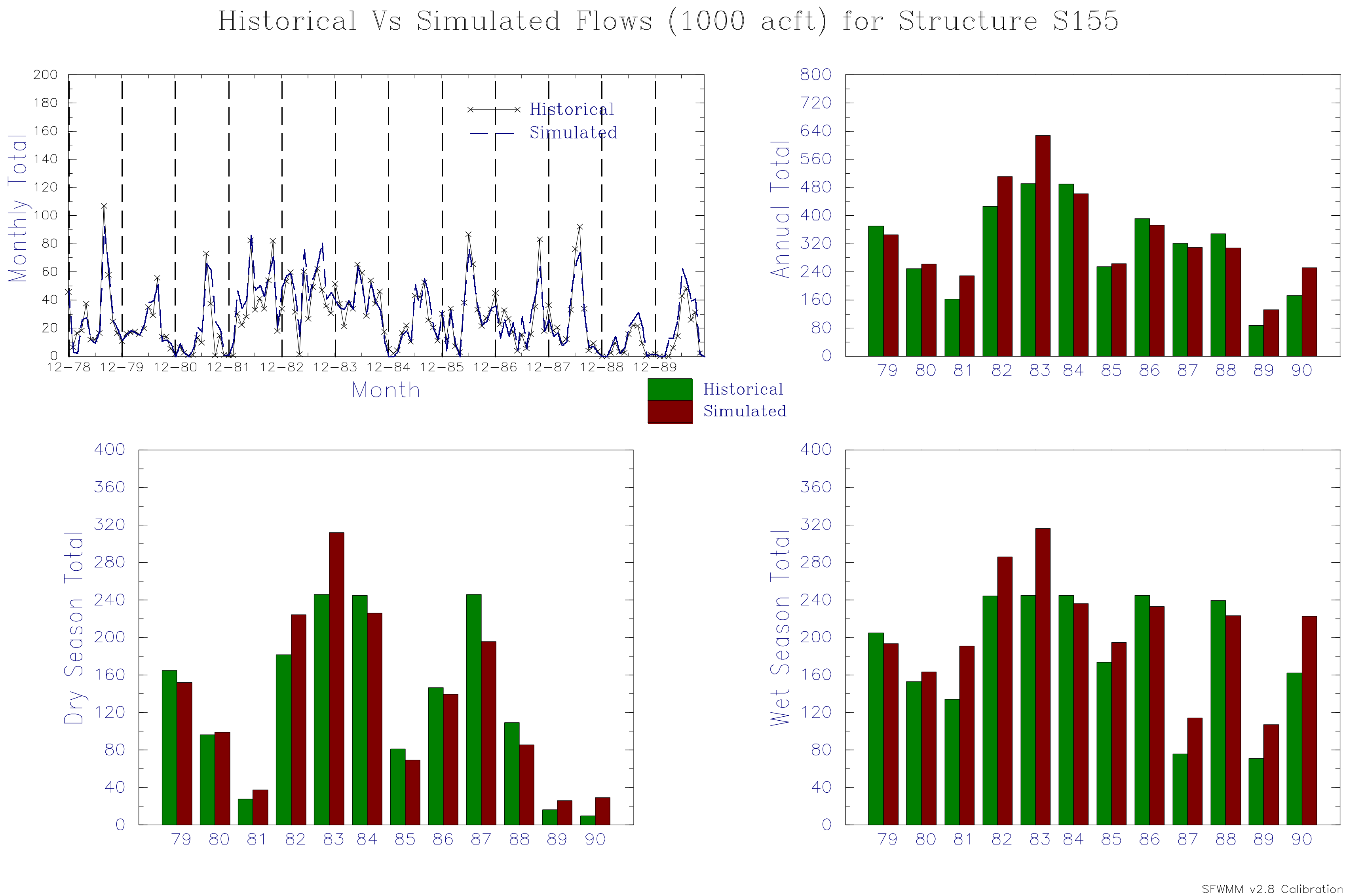

Figure 6.2.12 Comparison of Simulated and Historical Flows at Structure S-155 for Period of Record 1979-1990